OF PHEASANTS AND FRITILLARIES: IS PREDATION BY PHEASANTS (*PHASIANUS COLCHICUS*) A CAUSE OF THE DECLINE IN SOME BRITISH BUTTERFLY SPECIES?

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Summary

Published evidence concerning the hypothesis that pheasant predation is implicated in the decline of the heath fritillary (*Mellicta athalia*) is discussed.

Nineteen species of British butterfly which have declined in range since 1969 are assigned to 'risk of predation by pheasant' categories based on features of the butterflies' ecology.

Seven of these species are shown to have a statistically significant negative correlation between 10 km map squares from which the species has been lost and the density of pheasants in these squares. These are seven of the 11 species here assigned 'high-risk' scores on life-cycle information.

None of the eight species assigned low-risk scores showed a significant negative correlation with pheasant density.

The hypothesis of a causal relationship between pheasant density and the decline of 'high-risk' butterfly species is discussed. Further experiments which test the hypothesis are suggested.

The heath fritillary and pheasants

The heath fritillary at Abbots Wood near Eastbourne 'suffered greatly in the larval stage from the depredations of pheasants now more extensively preserved': so said a Mr Carpenter in a discussion on the protection of insects in danger of extinction at a meeting of the South London Entomological and Natural History Society in 1897 (Turner, 1897). This seems to be one of the earliest suggestions that artificially increasing the density of pheasants could be detrimental to butterflies. It was made at a time of great increase in the game preservation industry, when gamekeepers were being blamed for the disappearance of many predatory mammals and birds. The charges against the gamekeepers were comprehensively proven in the famous paper by Langley & Yalden (1977). The charges against the pheasants appear to have been dropped without trial. My purpose in this paper is to argue that the circumstantial evidence is sufficient to demand that the trial be re-opened.

It is following the paper by Warren, Thomas & Thomas (1984) that recent authors have tended to dismiss the possible significance of pheasant predation on endangered butterflies. They quoted three authors who suggested pheasants as possible culprits in the case of the heath fritillary (Frohawk, 1924; Stokoe, 1944; Ford, 1945) and dismissed these claims as follows: 'Stokoe (1944) and Ford (1945) . . . are probably only quoting Frohawk. None of these authors gives any direct evidence and their comments seem based purely on the general fact that the birds are known to eat ground-living insects. . . .'. Warren *et al.* (1984) and Warren (1987) provide convincing proof that habitat structure is a major influence on heath fritillary

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[1] This paper is based upon a talk to be given to the Society on 14 December 1989.

populations. This seems to have been taken as an adequate justification for dismissing the possibility that pheasants are also part of the story. Their comments on Frohawk and Stokoe seem less than fair.

Frohawk quotes as evidence the rapid decline of the heath fritillary in Chattendon Woods, Kent in the final quarter of the 19th century coincident with the increase in pheasant rearing in the area. Stokoe quotes not Frohawk but a report from Dr G.H.T. Stovin concerning a colony of heath fritillaries in Essex: 'the last colony in Essex died out owing to the woods in question being used for game preservation'. We thus have three separate cases, in three counties, of a rapid decline in heath fritillaries following an intensification of game preservation: hardly a case of many authors copying the (mis)information contained in a single publication as Warren *et al.* (1984) imply. Ford (1945) boldly stated that 'pheasants are even more deadly enemies to it than unscrupulous collectors' but gives no reference or evidence. He may well have been repeating Frohawk as Warren *et al.* suggest.

Warren (1987) reports a most detailed study of the ecology of the heath fritillary including an attempt to measure the mortality rates and causes. Larval mortality could not be measured—so the results are obviously incomplete, but none-the-less extremely interesting. Egg batches contained between 60 and 100 eggs. Females may lay more than one batch but, even if few females live long enough to do so, an average of 80 eggs per reproducing female seems a minimal estimate. Just under 6% of eggs failed to hatch in the field (mostly disappeared, assumed predated, predator unknown). The mortality in the pupal stage was higher—around 50%. Some of this was due to parasitoid insects but most from predators assumed to be small mammals and beetles. Most pupae assumed to be predated by small mammals simply disappeared and could possibly have been bird predated. Others left clear remains similar to those left when beetles or mammals consume the pupae in captivity.

From Warren's estimates of egg and pupal mortality, and my assumption of a minimum of 80 eggs per female and assuming that mortality of adult butterflies before egg-laying is not massive, it follows that larval mortality must be about 90% if heath fritillary populations are not to increase dramatically each year. This is hardly surprising since the larval stage is the overwintering stage and has by far the longest duration of the four life-cycle stages. It is thus particularly sad that Warren was unable to measure the causes of larval mortality. It is noticeable that most heath fritillary colonies survive (or have been successfully introduced) in nature reserves—areas where both the habitat management can be adjusted to the needs of the butterfly and where pheasant rearing and release does not take place. It thus seems wrong to assume, in the absence of any evidence, that pheasant predation is quite unimportant and that habitat structure is the only thing that matters.

Bird predation and butterflies

That many species of British butterflies have declined in range during the present century (especially during the last 30 years) is well known. The cause(s) of these declines has been the subject of much discussion usually concerned with establishing the relative importance of habitat change, habitat fragmentation, pesticides and pollution, climatic variation and butterfly collecting. Thomas (1984) gives a particularly valuable review of these topics but it is noticeable that the possible significance of bird predation is scarcely mentioned in this and some other papers concerned with butterfly declines. A review by Dempster (1984) indicates that, in those few species that have been studied, predation by birds is a significant cause of mortality especially in the later larval instars and the pupal stage. Pollard (1979) has suggested that the association between cool spring and summer temperatures and declines in the range of the white admiral (*Ladoga camilla*) may be the result of low temperatures slowing development and thus lengthening the time during which larvae and pupae are exposed to bird predation. Pratt (1983) concluded that increased predation by birds may well have been an important cause of the decline to extinction of the black-veined white (*Aporia crataegi*).

For predators to cause significant declines in their prey it is necessary that the predators have increased in abundance and that the predator population is not limited by prey availability. Pheasants (*Phasianus colchicus*) fulfil both these conditions.

WHY PHEASANTS?

Pheasants are not native to the British Isles. Probably introduced to England in the 11th century they did not become widespread throughout the British Isles until the late 19th century. Although the species can survive in the feral state without assistance by man, game preservation and release of captive reared birds substantially increases the population density (Sharrock, 1976). Game preservation directed at increasing pheasant density became widespread in lowland Britain during Victorian times. There were declines in the amount of pheasant rearing and game preservation activities during the two war periods during this century and corresponding declines in the abundance of pheasants were noticed (Sharrock, 1976). In recent decades there has been a substantial increase in the numbers of captive bred pheasants released; now about 15 million birds are released annually (Lack, 1986): these exceed the total biomass of native insect-eating and mixed-diet terrestrial-feeding birds in Britain. Table 1 shows that, in biomass terms, the pheasant is the dominant species of potential butterfly-predating birds in the British Isles. It should be pointed out that biomass is a rather crude indication of likely impact on insects: larger birds may well have a smaller proportion of insect prey in their diet. Also, small birds have a higher heat loss rate than large ones and in consequence eat more per gram of body weight than large ones. Even so, if any bird has an effect on butterfly populations, it is likely that the pheasant does.

METHODOLOGY

The butterfly species included in this analysis were all the 18 species listed by Heath, Pollard & Thomas (1984) as showing a major contraction of range. In addition, *L. camilla* was included as their map indicates a considerable contraction in range although they put it in their 'contraction and equal of greater re-expansion' category.

Pheasants feed only at ground level and are not such a major part of the bird community in short downland turf habitats as they are in wood, scrub and rough grassland habitats (Fuller, 1982). It is thus a reasonable *a priori* assumption that butterflies whose larvae and pupae live entirely in the tree or shrub canopy will be immune to predation by pheasants. Of those whose larvae are sometimes within reach of pheasants it seems reasonable to suggest that woodland species will be at greater risk than downland ones. That camouflaged larvae and pupae will be at lesser risk than gregarious or non-camouflaged forms is debatable: the gregarious larvae may be distasteful to birds and have some protection. On the basis that birds need to learn to avoid distasteful prey, and that pheasants are released as inexperienced young birds likely to peck at anything moving at ground level, I have assumed that

Table 1. Biomass of insect-eating birds in the British Isles.

Species	Percentage total biomass		Total biomass (tonnes)	
	Winter	Summer	Winter	Summer
Pheasant *Phasianus colchicus* L.	39	12	8800	1100
Starling *Sturnus vulgaris* L.	14	13	3034	1148
Blackbird *Turdus merula* L.	8	15	1710	1330
Crow *Corvus corone* L.	9	12	1995	1140
Rook *Corvus frugilegus* L.	9	11	1960	980
Song thrush *Turdus philomelos* L.	3	6	656	574
Skylark *Alauda arvenis* L.	4	3	975	234
House sparrow *Passer domesticus* (L.)	2	3	351	319
Dunnock *Prunella modularis* (L.)	2	2	420	210
Robin *Erithacus rubecula* (L.)	1	1	190	133
Great Tit *Parus major* L.	1	1	180	108
Magpie *Pica pica* (L.)	1	1	157	135
Blue Tit *Parus caeruleus* L.	1	1	150	100
Wren *Troglodytes troglodytes* (L.)	1	1	150	100
Chaffinch *Fringilla coelebs* L.	0	2	0	210
Grey Partridge *Perdix perdix* (L.)	0	2	0	160
Red Partridge *Alectoris rufa* (L.)	0	2	0	146

This table is derived from: (a) The estimates of total British & Irish populations (breeding and wintering) given in Lack (1986) and Sharrock (1976). Where a range of figures is given the mid-point of the range was used. (b) The typical weights given in Perrins (1987). Where a range of weights is given the mid-point was used. Where male and female weights are different a mean figure was used. (c) The indications of diet given in Perrins (1987). All species noted as including insects as a normal part of their diet were included except those that feed in aquatic habitats or on the wing only. Those (e.g. partridge and many finches) which are herbivorous in winter but feed on insects in summer were included in the summer figures only. (d) The data for all 100 species were used in the calculations but the table includes only those species with an average of 1% or more of the total biomass.

Notes to Table 2.

1. *L. sinapis* larvae prefer the taller specimens of their foodplants. Mean height of pupation is 20–40 cm (Heath & Emmet, 1989). Thus the true risk score may be lower.
2. It is the ground level pupa of *T. betulae* which is most at risk, but most larvae feed low on bushes oviposition being in range 20–100 cm (Heath & Emmet, 1989).
3. *H. lucina* now survives almost exclusively in non-woodland habitats but was originally a woodland species (Heath & Emmet, 1989).
4. *A. aglaja* does colonize woodlands but its main habitats are windswept downlands and coastal sites (Heath & Emmet, 1989).
5. The young larva hibernates on tree trunks where it may be out of reach to pheasants. It descends to feed early in the spring (Heath & Emmet, 1989): hence the high risk score.
6. *E. aurinia* also inhabits woodland rides and scrubby areas so a higher score than given here could be justified.
7. Most strong *M. galathea* colonies are on downland and coastal habitats — hence the score given here despite the existence of some woodland ride populations.

Table 2. Degree of risk from pheasant predation for those British butterflies which have declined in range.

Species	Column a	Column b	Column c	Column d	Overall score
Chequered skipper *Carterocephalus palaemon* Pall.	1	1	1	0	3
Silver-spotted skipper *Hesperia comma* (L.)	1	1	0	0	2
Wood white *Leptidea sinapis* (L.)	1	1	1	0	3 (note 1)
Brown hairstreak *Thecla betulae* (L.)	1	1	1	0	3 (note 2)
Small blue *Cupido minimus* (Fuess.)	1	1	0	0	2
Silver-studded blue *Plebejus argus* (L.)	1	0	0	0	1
Adonis blue *Lysandra bellargus* (Rott.)	1	1	0	0	2
Duke of Burgundy *Hamearis lucina* (L.)	1	1	1	0	3 (note 3)
White admiral *Ladoga camilla* (L.)	0	na	na	na	0
Purple emperor *Apatura iris* (L.)	0	na	na	na	0
Large tortoiseshell *Nymphalis polychloros* (L.)	0	na	na	na	0
Sm. Pearl-brd fritillary *Boloria selene* (D. & S.)	1	1	1	1	4
Pearl-brd fritillary *Boloria euphrosyne* (L.)	1	1	1	1	4
High Brown fritillary *Argynnis adippe* (D. & S.)	1	0	1	1	3
Dark-green fritillary *Argynnis aglaja* (L.)	1	1	0	1	3 (note 4)
Silver-washed fritillary *Argynnis paphia* (L.)	1	1	1	1	4 (note 5)
Marsh fritillary *Eurodryas aurinia* (Rott.)	1	1	0	1	3 (note 6)
Heath fritillary *Mellicta athalia* (Rott.)	1	1	1	1	4
Marbled white *Melanargia galathea* (L.)	1	1	0	0	2 (note 7)

This table shows a "risk-score" based on four aspects of the biology of the species as recorded by Thomas (1986). The arbitrary scoring system is: (a) Larva and/or pupa occurs near enough to ground to be accessible by pheasants, (yes: score 1 plus scores in other columns; no, score 0 overall). (b) Larva and/or pupa accessible to pheasants during July–March, time of high pheasant abundance, (yes, score 1; no, score 0). (c) Woodland habitat normally (score 1), downland/heathland habitat normally (score 0). (d) Larva gregarious and/or not well camouflaged (score 1), larva camouflaged (score 0).

the non-camouflaged larvae will be at greater risk than those which are more difficult to see (but which are probably more palatable). Finally, since pheasant populations are substantially higher during autumn and winter than during late spring and summer (Lack, 1986) it seems reasonable to assume a greater risk for those species which overwinter in the larval or pupal stage.

Based on the above *a priori* assumptions, each of the 19 butterfly species was given a 'risk-score' between zero and four (Table 2).

The data used for the analyses in Table 3 came from the published distribution maps for pheasants (Lack, 1986) and butterflies (Heath, Pollard & Thomas, 1984). Both surveys use the 10 km squares of the national grid to plot distribution surveys. The pheasant map was based on the BTO winter birds survey conducted in the winters 1981/2 and 1982/3. Squares with pheasants were assigned to one of three density categories based on the number of pheasants seen during a standardized period of search. The butterfly maps indicate, for each square with any known occurrence of the species, the date class of the most recent record.

The data from each map was entered into a micro-computer and a contingency table calculated showing the date of the most recent butterfly record against the pheasant density for all 10 km squares for which the butterfly species had ever been recorded. An index indicating the size and direction of any correlation between pheasant density and date-class of most recent record was calculated — see Table 3.

RESULTS

Table 3 shows the results of a standard chi-square test with the MICROTAB program (Higginbotham, 1985); the null hypothesis being no association between pheasant density and presence of the butterfly in recent times. Eight of the 19 species show a significant deviation from expectation ($P < 0.05$) and in all but one of these (*Hamearis lucina*) the direction of the deviation was a negative correlation (i.e. squares with high pheasant densities are less likely to have a recent record of the butterfly than would be expected by chance).

In every one of the eight species in the low-risk categories 0 to 2 there was no significant deviation from the null hypothesis expected values. In other words, it is reasonable to accept that whether or not a butterfly has survived in a given square is quite unrelated to the density of pheasants in that square. (Although there is some indication of a weak positive correlation in *Apatura iris*). Seven of the 11 species in high-risk categories 3 and 4 show significant negative correlation with pheasants. An additional two species in these 'high-risk' categories show some negative correlation but not strongly enough to give a P value below 0.05. For these species, there was less than average chance that each would survive to the time of the recent survey in squares with a high pheasant density.

DISCUSSION

Interpretation of dot-distribution maps is easy to criticize: the maps reflect the distribution of recorders, the butterfly maps do not distinguish between a single wandering individual and a strong resident population, the bird and butterfly surveys were conducted at different times and quite probably in different parts of each surveyed 10 km square. It is worth pointing out that every one of these criticisms is valid and that the effect of each would be to hide any real relationship between two maps with 'random-noise'. That a strong negative correlation between survival of the butterfly to recent times and high pheasant density is demonstrable, despite these sources of random effects, is added reason to be convinced that the link is genuine.

Table 3. Butterfly survival and pheasant density.

For each species a 3 × 4 contingency table was constructed showing the numbers of 10 km squares (n) in each of three butterfly record-date classes (the dates of the most recent record: pre-1940; 1940–1969; 1970–1982) against the density of pheasants in those squares. The data sources for the butterflies are the maps in Heath, Pollard & Thomas (1984) and Lack (1986) for the pheasants.

Using the Microtab program (Higginbotham, 1985) each contingency table was tested for departure from the numbers expected in each cell of the table (null hypothesis: no correlation between pheasant density and survival of butterflies to recent times). Where the expected numbers in a cell fell below five, it was necessary to amalgamate the "no-pheasant" and "low-pheasant" rows to permit the statistical testing. The numbers of degrees of freedom (df) indicates when this has been necessary. A 3 × 4 table has df=6; a 3 × 3 table df=4. In the case of the heath fritillary all pre-1970 records had to be amalgamated leaving a 2 × 3 table (df=2). The chi-squared value and its associated P value indicate whether departure from the null hypothesis is indicated. If $P<0.05$ the null hypothesis was rejected.

A single index of association is given for each species. This was obtained by grouping the results into a 2 × 2 table (no + low pheasants or medium + high pheasants against old records only or post-1969 records). The chi (as opposed to chi-squared) value is used as the index as it carries a sign indicating whether the association is negative (butterflies are less likely to survive to recent times in squares where pheasant density is high than the laws of chance would suggest) or positive.

Full contingency tables are available from the author. Here, the results are summarized with the species presented in sequence based on the degree of negative association detected. Species asterisked show a statistically significant departure from a random association.

	n	Chi-sq	d.f.	*P*	Index
*Silver-washed fritillary	886	64.53	6	$P<0.001$	−6.12
*Dark green fritillary	1192	39.65	6	$P<0.001$	−5.07
*Chequered skipper	88	32.61	4	$P<0.001$	−4.91
*Marsh fritillary	628	30.88	6	$P<0.001$	−4.17
*Brown hairstreak	364	32.61	6	$P<0.001$	−3.42
*Small pearl-bordered	959	47.11	6	$P<0.001$	−3.17
Wood white	533	9.59	6	$0.95>P>0.1$	−2.07
High brown fritillary	415	9.20	6	$0.1>P>0.05$	−1.62
*Pearl-bordered fritillary	716	12.73	6	$0.05>P>0.025$	−1.50
Silver-spotted skipper	118	8.13	4	$0.1>P>0.05$	−0.93
Adonis Blue	174	8.33	4	$0.1>P>0.05$	−0.70
Large tortoiseshell	379	3.74	4	$0.95>P>0.1$	−0.54
Heath fritillary	73	3.81	2	$0.95>P>0.1$	0
Silver-studded blue	312	2.84	6	$0.95>P>0.1$	0
Marbled white	575	7.48	4	$0.95>P>0.1$	+0.36
Small blue	486	6.21	6	$0.95>P>0.1$	+0.98
White admiral	382	3.56	4	$0.95>P>0.1$	+1.27
Purple emperor	225	8.48	4	$0.1>P>0.05$	+1.46
*Duke of Burgundy	259	10.44	4	$0.01>P>0.025$	+2.12

The programs used for this and the other analyses reported here are available (Corke, 1988) and can be used for investigating these correlations further and also for more general biological mapping.

It is also worth noting that the combined picture of distribution and decline for the 'high-risk' species is very different from that of the 'low-risk' species. This is illustrated by the distribution maps (Figs 1–6). The low-risk species are concentrated in southern-central England and have contracted further into that area. This is entirely consistent with the widely accepted explanations of the combined influence of deteriorating climate and loss of rich (mainly downland) habitats. The 'high-risk'

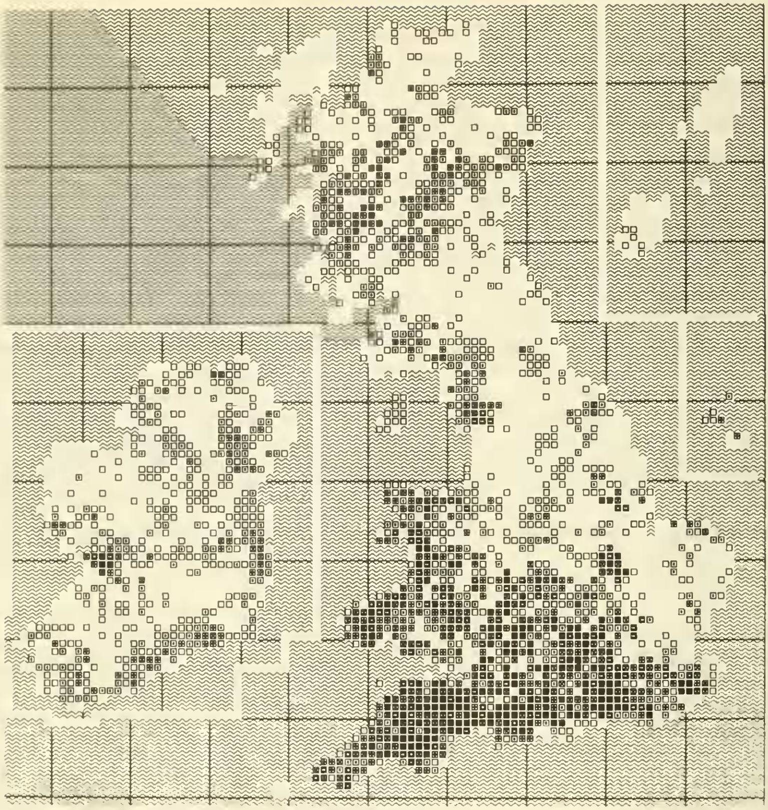

Fig. 1. 10 km sq map showing the total number of the 11 butterfly species in "risk" categories 3 and 4. □=1, ⊡=2, ⊞=3, ☒=4, ▣=5, ■=6.

species, in contrast, have a westerly bias to their distribution with no indication that they avoid the wet and cold areas of Britain. Their contraction has been mainly noticeable in the east of their range. This cannot be explained in climatic terms but parallels very closely what happened to many predatory birds and mammals in consequence of game-preservation (Langley & Yalden, 1977).

The negative correlations detected for the high-risk species are most unlikely to result from chance. That does not, of course, prove that the relationship is one of cause and effect. It could reasonably be argued that the decline of some butterfly species has resulted from habitat fragmentation, habitat change due to agricultural practices or pesticides associated with agriculture. Since pheasant shooting (and therefore rearing) is a favoured pastime of the richer members of the agricultural community, one would expect that a high pheasant density be associated with the intensive agriculture of eastern England. These areas may have become unfavourable to butterflies because of the agricultural changes and associated loss of actively coppiced woodland. This is the most generally acccepted reason for the decline of this group of species. If this is the main explanation of the correlation between

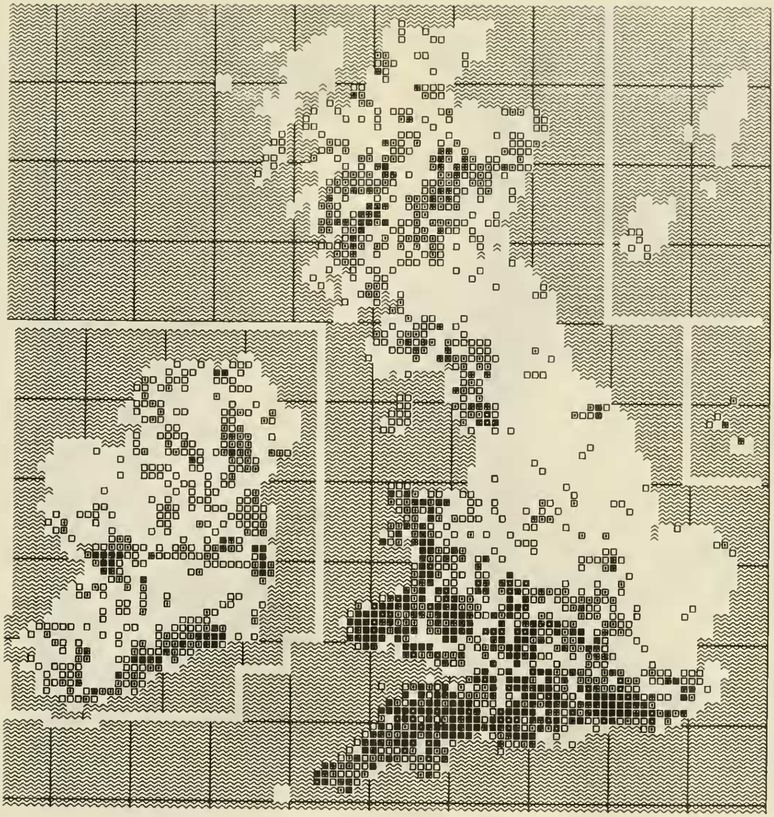

Fig. 2. 10 km sq map showing the number of the 11 butterfly species in "risk" categories 3 and 4 for which there is a post-1969 record. For symbols see Fig. 1.

pheasant density and butterfly decline reported here, then it is remarkable that the correlation is found only in those species whose biology exposes them to the risk of direct predation by pheasants and not those which pheasants cannot attack (but which would be susceptible to agricultural changes presumably).

On the basis of the information presented here, it seems reasonable to conclude that, for at least five species of fritillary butterfly (asterisked in Table 3) and perhaps two other woodland species (*Thecla betulae* and *Carterocephalus palaemon*) pheasant predation may be a significant cause of their decline (in combination, no doubt, with changes in woodland habitats associated with reduced coppicing and increased separation of suitable woodlands). For the declining species of downland habitats and the high woodland canopy pheasants are clearly not responsible and one would not expect them to be. The well-established habitat changes on downlands and heathlands (related to agricultural changes and reduction of rabbit grazing) are sufficient explanation for five species. The decline of three tree/shrub feeding species may, perhaps, be related to climatic change.

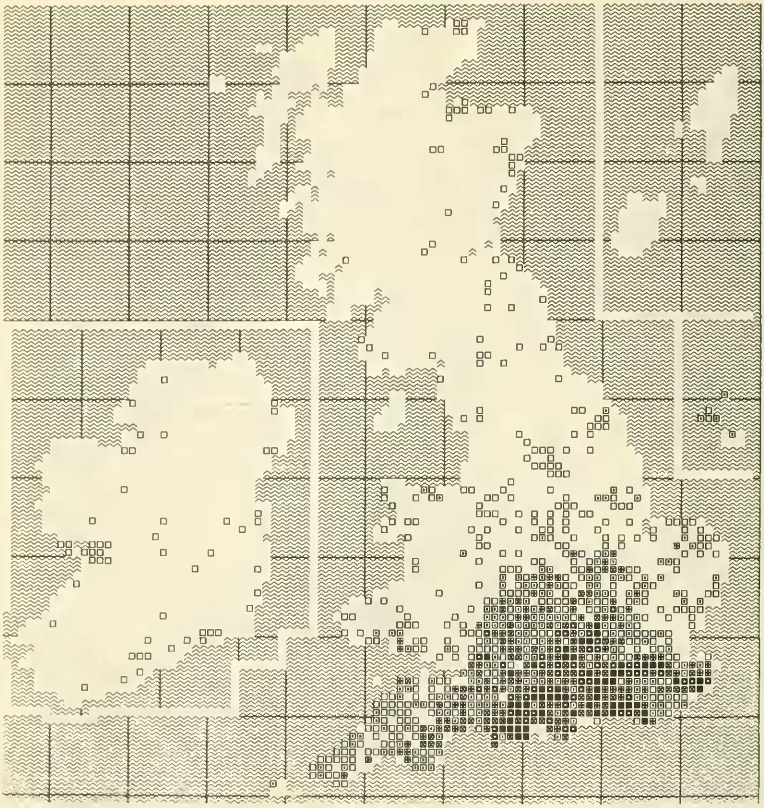

Fig. 3. 10 km sq map showing the total number of the eight butterfly species in "risk" categories 0 to 2. For symbols see Fig. 1

The heath fritillary does not show any correlation (positive or negative) in this analysis. The total number of squares involved in the analysis is very low for this species — probably too low for this crude form of analysis to be of any use. The evidence discussed in the first section of this paper does, though, suggest that pheasant predation could be important.

The Duke of Burgundy (*Hamearis lucina*) is one species which does not fit this hypothesis. Its biology suggests that it should be susceptible to pheasant predation in wood and wood-edge habitats and yet it shows some positive correlation between high pheasant density and survival. It is a rapidly declining species and survives best in non-woodland habitats. Recent surveys show that it has disappeared from virtually all its woodland haunts and survives mainly on 'poorly grazed calcareous grassland' (Heath & Emmet, 1989) which may explain this anomaly. I predict that, in studies at a more local level than 10 km squares, this species will be shown to survive better in low pheasant density woodlands. If this prediction is shown to be false it will be an excellent argument against my hypothesis.

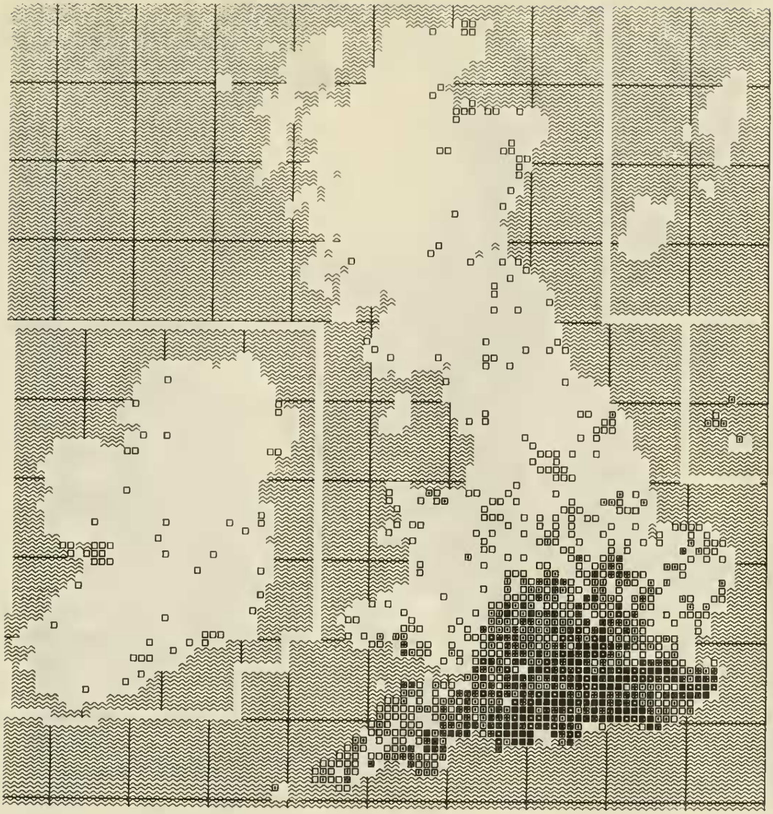

Fig. 4. 10 km sq map showing the number of the eight butterfly species in "risk" categories 0 to 2 for which there is a post-1969 record. For symbols see Fig. 1

A number of other predictions follow from the hypothesis of a causal link between the decline of woodland and scrub-habitat butterflies whose immature stages exist at ground level and predation by pheasants. The following three predictions could be tested quite simply and would serve to confirm or reject the hypothesis presented here.

1. The density of 'at risk' species should be significantly lower in otherwise equivalent habitats which have a high pheasant density than in low pheasant density woods. The standard monitoring techniques (Pollard, Hall & Bibby, 1986) could be used to test this prediction if the monitored sites can be surveyed for pheasant density.
2. The density (and number of species) of butterflies will decline in existing 'good' woodland habitats if pheasant release is started or intensified in these woodlands.
3. Attempted re-introduction of species to woods from which they have been lost will succeed more often in woods with low pheasant density during the re-introduction experiments.

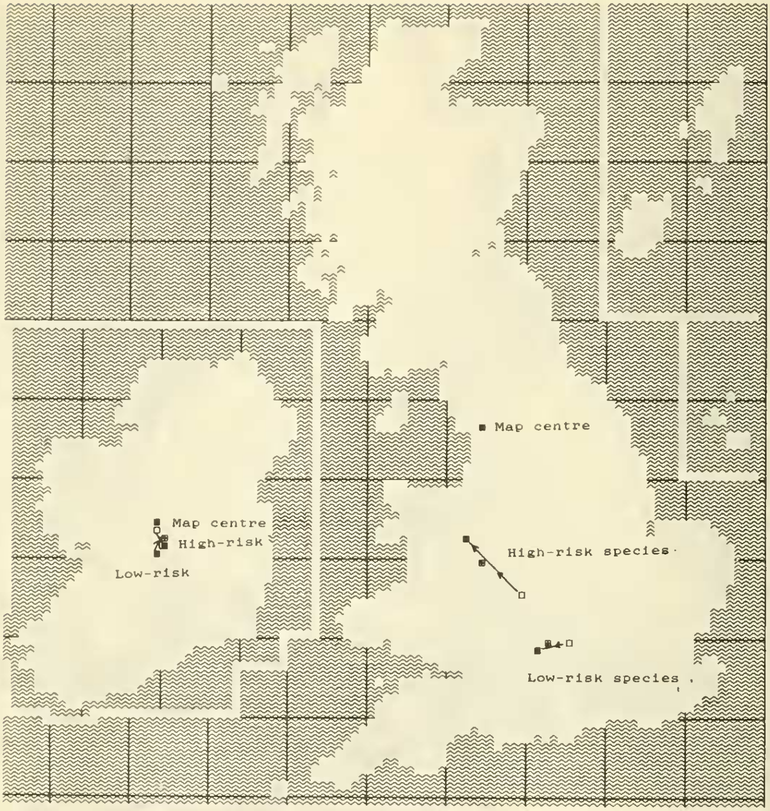

Fig. 5. Map showing shifts in the range centres of "high-risk" and "low-risk" species. The map centres are calculated separately for Ireland and for Britain (including its offshore islands except Orkneys, Shetlands and Channel Isles). The results for Ireland indicate a random scatter of records for both groups, no real shift in range centres and range centres close to the geographic centre of Ireland. The results for Britain indicate a distinct shift to the north and west in the ranges of the "high-risk" species and a lesser shift to the west (and south?) for the low risk groups. Both groups still have range centres to the south of the geographic centre of Britain and this is very pronounced in the "low-risk" species. ■ = recent research, ⊞ = total records, □ = last species.

IMPLICATIONS FOR BUTTERFLY CONSERVATION

Recent research by the Game Conservancy Trust (Robertson, Woodburn & Hill, 1988) has shown convincingly that the management of woodlands for pheasants has a positive effect on the numbers of adult butterflies seen in the wood. The authors do not, of course, make any claim that the pheasants themselves are beneficial to butterflies. It is because the requirement of pheasants are best met by an open woodland structure and wide rides that 'pheasant woods' are better than uncoppiced woods or conifer plantations. The published work does not compare the density of

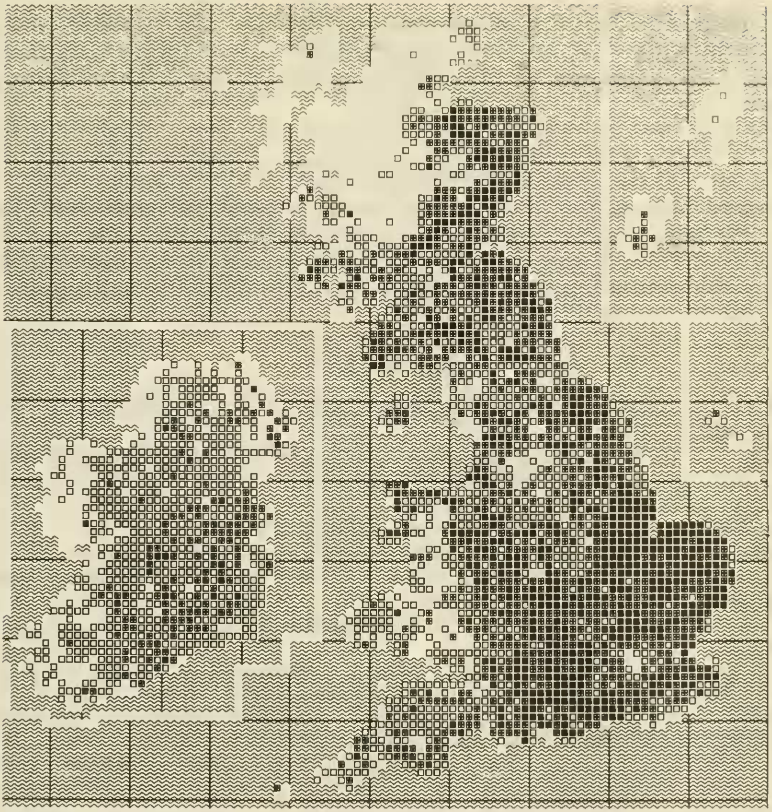

Fig. 6. The 10 km square map of pheasant density (from Lack, 1986) used for the analyses in Table 3. ■ = high, ⊞ = medium, □ = low.

butterflies in open coppiced woods managed as nature reserves with structurally similar woods managed for pheasants. Such a comparison would be most valuable. The butterfly species recorded by Robertson *et al.* contained only two species in my 'high risk of pheasant predation' category in their study woodland.

Meanwhile, the positive links between woodland management for pheasants and butterfly conservation are being widely publicized. I feel there is some risk that the managers of nature reserve woods (especially when these are poorly funded County Wildlife Trusts with strong influence from the field sports lobby) may be tempted to permit the use of nature reserves for pheasant rearing as a way of increasing income. It is my view that such action would be most unwise. While it is true that a wood managed for pheasants is better than no wood or a derelict and overgrown wood, there is no evidence that it is better than a properly coppiced wood with a low pheasant density. The evidence presented here suggests that the reverse applies.

In conclusion, I regard it as important that the case of the pheasant and the fritillary be re-opened by the funding of suitable study along the lines suggested in this paper. Only then will the accusation made over 90 years ago be confirmed or rejected.

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